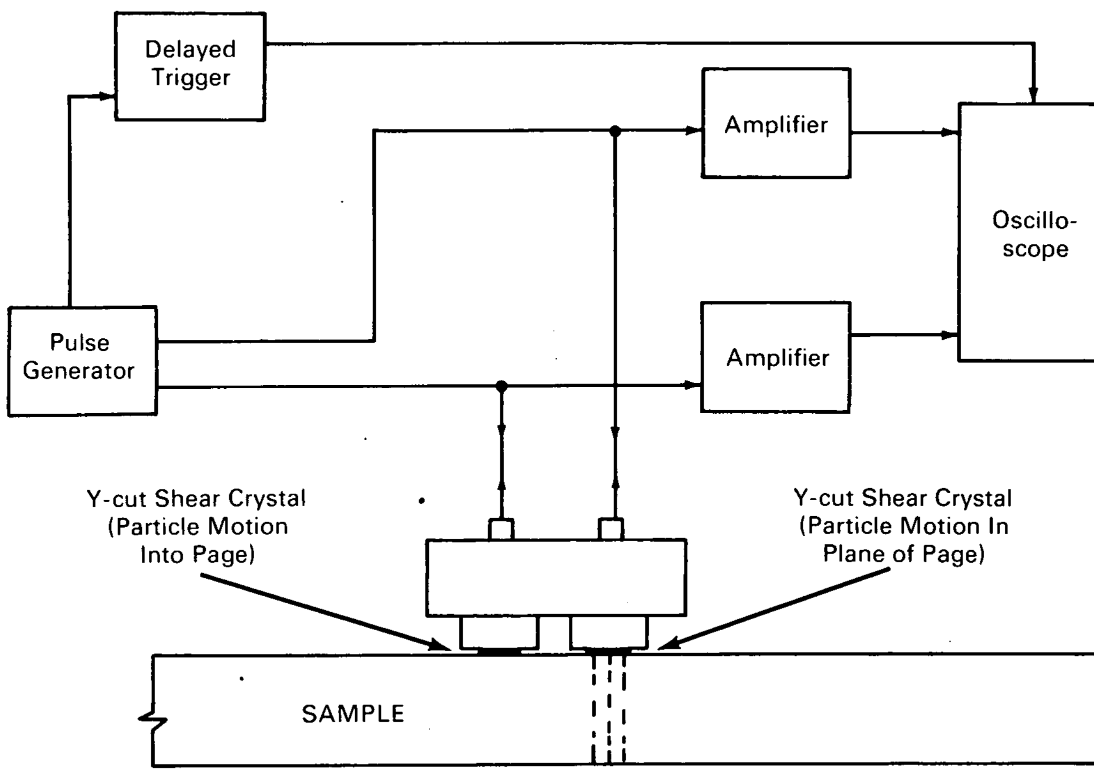
NASA TECH BRIEF

Ultrasonics Used to Measure Residual Stress



The problem:

Residual stress in metal structures can result from machining or assembly processes to cause fatigue failures. Residual surface stress lends itself to X-ray analysis, and dynamic surface stresses are observable with strain gage and photostress techniques, but residual stress levels within a metal are not susceptible to such determinants.

The solution:

An ultrasonic method of stress analysis in which the waves propagate readily in metals, various forms of propagation are possible, and more thorough analysis of complex geometric structures may be had.

How it's done:

Two Y-cut crystals are mounted with their axes of vibration at right angles. The crystals generate and receive signals and a phase comparison reveals changes in velocity. The amount of phase shift between the two signals is then proportional to the average stress difference between the two directions of vibration. While laboratory tests performed to date have dealt with uniaxial loads, the single side type of transducer enables

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not only the principal direction of stress to be established but also its magnitude. For example, if the direction of stress in a sample is in the direction of its particle vibration related to one of the crystals, the maximum differential change occurs. Orienting the transducers by 45° should then show no change since each component of the shear wave sees the same amount of stress. By this means, calibration of a zero relative stress may be made.

Not only do shear waves show a velocity-stress dependence but also surface waves. Surface waves are extremely useful in studying surface stress, surface conditions (oxidation), and stress gradients. Measurements concerning surface waves are affected by strain with one half of the change in the time of wave travel due to stress and the remainder resulting from path length change due to strain. Field measurements are readily corrected for this phenomenon by calibration. Stresses that are present near the surface of a material and vary in depth can be measured by varying frequency, the penetration depth of a surface wave is approximately one wavelength or, expressed differently, with a surface wave velocity of 3×10^3 m/sec, the depth of penetration is 0.3 cm at 1 MHz or 0.03 cm at 10 MHz.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B67-10428

Patent status:

No patent action is contemplated by NASA.

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